Amendments to the Specification:

Page 13, line 8

The free layer 130 is ferromagnetic and is configured to have a high perpendicular anisotropy. As used herein, a high perpendicular anisotropy occurs for the simple free layer 130 when the perpendicular anisotropy of the free layer 130 has a corresponding perpendicular anisotropy energy that is at least twenty percent and less than one hundred percent of the demagnetization energy. Figure 2B depicts a magnetic element 100' that is analogous to the magnetic element 100. Thus, analogous components are labeled similarly. The magnetic element 100', therefore, includes a free layer 130' that can be written using spin transfer and that has a high perpendicular anisotropy. However, the free layer 130' is synthetic, including two ferromagnetic layers 132 and 136 separated by a nonmagnetic layer 134 that is preferably Ru. The nonmagnetic layer 134 is configured so that the magnetizations 133 and 137 of the free layer 130' are aligned antiparallel. The free layer 130' has a high perpendicular anisotropy because the the the ferromagnetic layers 132 and 136 have a high perpendicular anisotropy. Thus, the perpendicular anisotropy of the ferromagnetic layers 132 and 136 corresponds to a perpendicular anisotropy energy that is at least twenty percent and less than one hundred percent of the demagnetization energy of the ferromagnetic layers 132 and 136, respectively. Referring to Figures 2A and 2B, the high perpendicular anisotropy is defined to have a perpendicular anisotropy energy that is at least twenty percent but less than one hundred percent of the demagnetization energy. Consequently, although the perpendicular anisotropy is substantial, the equilibrium magnetization of the free layer 130 or the constituent ferromagnetic layers 132 and 136 lie in plane (no components up or down in Figures 2A and 2B). For clarity, the discussion

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below primarily refers to the free layer 130. However, the principles discussed also apply to the

free layer 130', including ferromagnetic layers 132 and 136, and the magnetic element 100'.

Page 17, line 6

Figure 3A depicts another version 100'' of the first embodiment of a portion of a

magnetic element in accordance with the present invention having a reduced write current density

for spin transfer switching. The magnetic element 100'' is analogous to the magnetic element

100. Thus, analogous components are labeled similarly. Therefore, the magnetic element

includes a free layer 130'' that has a high perpendicular anisotropy and which is written using

spin transfer. Moreover, the magnetic element 100'' preferably utilizes two terminals (not

shown) near the top and bottom of the magnetic element. However, nothing prevents the use of

another number of terminals, for example a third terminal near the center of the magnetic

element. In a preferred embodiment, the free layer 130'' includes Co, CoCr, CoPt, CoCrPt,

CoFe, CoFeCr, CoFePt, CoFeCrPt, or their multilayer combinations, which have an intrinsic

high perpendicular anisotropy. The magnetic element 100'' also includes optional stress

increasing layers 152 and 154. One or both of the stress increasing layers 152 and 154 may be

used. The layer 154 is used to alter the stress and the surface anisotropy of the free layer 130'',

leading to further enhancement of the total perpendicular anisotropy. The stress increasing layer

152 is a seed layer that also enhances the total perpendicular anisotropy of the free layer 130''.

The stress increasing layer 152 may act as part of the spacer layer 152 120'' when the spacer

layer 152 120'' is conductive. However, if the spacer layer 120'' is an insulating barrier layer,

the inclusion of the stress increasing layer 152 can cause a significant degradation in signal. In

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such an embodiment, the stress increasing layer 152 is, therefore, undesirable. The stress increasing layers 152 and 154 may include a few Angstroms of materials such as Pt, Pd, Cr, Ta, Au, and Cu that further promote perpendicular anisotropy in the free layer 130''. However, note that the use of Pt and Pd either within the free layer 130'' or adjacent layers 152 and 154 could increase the phenomenological Gilbert damping constant, α. An increase in α could negate some or all of the switching current density reduction brought about by high perpendicular anisotropy in the free layer ~~130''~~130''. In addition, the perpendicular anisotropy of the materials above, such as Co, CoCr, CoPt, CoCrPt, CoFe, CoFeCr, CoFePt, and CoFeCrPt, can be further increased by intrinsic stress in the film itself. This intrinsic stress may be induced during the film deposition and/or by surrounding the spin transfer stack (containing the free layer 130'') with an insulator (dielectric) of high compressive stress.

Page 18, line 14

Figure 3B depicts another version 100'''' of the first embodiment of a portion of a magnetic element in accordance with the present invention having a reduced write current density for spin transfer. The magnetic element 100'''' is analogous to the magnetic element 100. Therefore, the magnetic element 100'''' includes a free layer ~~130''~~130'''' that has a high perpendicular anisotropy, an optional low saturation magnetization, and which is written using spin transfer. Moreover, the magnetic element 100'''' preferably utilizes two terminals (not shown) near the top and bottom of the magnetic element. However, nothing prevents the use of another number of terminals, for example a third terminal near the center of the magnetic element.

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Page 19, line 22

The exchange-coupled combination of the very high perpendicular anisotropy sublayer 160 and the high spin polarization ferromagnetic layer provide a total high perpendicular anisotropy for the free layer 130'''. At larger thickness of the very high perpendicular anisotropy ferromagnetic layer 160, the total perpendicular anisotropy energy of the combination of the very high perpendicular anisotropy ferromagnetic layer 160 and the ferromagnetic layer 162 exceeds the total out-of-plane demagnetization energy for the very high perpendicular anisotropy ferromagnetic layer 160 and the ferromagnetic ~~layer162~~layer 162. In such a case, the magnetizations of both the very high perpendicular anisotropy ferromagnetic layer 160, the ferromagnetic layer 162 and thus the free layer 130''' would be oriented perpendicular to the film plane. If the thickness of the very high perpendicular anisotropy ferromagnetic layer 160 is reduced, however, the total perpendicular anisotropy energy of the very high perpendicular anisotropy ferromagnetic layer 160 and the ferromagnetic layer 162 is reduced faster than the total out-of-plane demagnetization energy of the very high perpendicular anisotropy ferromagnetic layer 160 and the ferromagnetic ~~layer160~~ 162. Stated differently, the total perpendicular anisotropy energy of the free layer 130''' is reduced more rapidly than the total out-of-plane demagnetization energy of the free layer 130'''. Alternatively, if the thickness of the high spin-polarization ferromagnetic 162 is increased, the total perpendicular anisotropy energy of the very high perpendicular anisotropy ferromagnetic layer 160 and the ferromagnetic layer 162 is increased more slowly than the total out-of-plane demagnetization energy of the very high perpendicular anisotropy ferromagnetic layer 160 and the ferromagnetic layer 162. Stated differently, the total perpendicular anisotropy energy of the free layer 130''' is increased more slowly than the out-of-plane demagnetization energy of the free layer 130'''. When the total

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perpendicular anisotropy energy becomes less than the total out-of-plane demagnetization energy, the equilibrium magnetizations of the very high perpendicular anisotropy ferromagnetic layer 160 and the ferromagnetic layer 162 rotate into the film plane. Stated differently, the perpendicular anisotropy energy of the free layer 130''' is less than the out-of-plane demagnetization energy of the free layer 130''' and the magnetization of the free layer 130''' is in plane even though the free layer 130''' has a high perpendicular anisotropy. Thus, to decrease the spin-transfer switching current, the thicknesses of the very high perpendicular anisotropy ferromagnetic layer 160 and the ferromagnetic layer 162 are tailored such that the total perpendicular crystalline anisotropy is high. Stated differently, the perpendicular anisotropy of the combination of the layers 160 and 162 has a perpendicular anisotropy energy that is at least twenty and less than one hundred percent of the demagnetization energy. In a preferred embodiment, this anisotropy energy is ninety percent of the total out-of-plane demagnetization energy. For example, in one embodiment, the magnetic element 100''' could be a top MTJ, having the free layer 130''' at the bottom closest to the substrate, the spacer or barrier layer ~~120''~~120''' and a pinned layer ~~110''~~110''' at the top. Such a magnetic element would include: very high perpendicular anisotropy ferromagnetic layer 160/ferromagnetic layer 162/spacer (barrier) layer 120'''/pinned layer 110'''/pinning or AFM layer (not shown). Thus, an example of the magnetic element 100''' is given by: AlCu[250A]/GdFeCo[t]/CoFe[10A]/Al2O3[8A]/CoFe[30A]/PtMn[150A], where the thickness, t, of GdFeCo is preferably adjusted between ten and four hundred Angstroms so that the that the total perpendicular crystalline anisotropy energy is between at least twenty and less than one hundred percent, preferably ninety percent, of the total out-of-plane demagnetization energy. Thus, the equilibrium magnetic moment of the free layer 130''' should remain in-plane.

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Page 23, line 21

The free layer 230 is preferably configured in a manner analogous to the free layers 130, 130', 130'', and/or 130'''. Thus, analogous materials and principles to those discussed above may be used to achieve the high perpendicular anisotropy of the free layer 230. Materials having a high crystalline perpendicular anisotropy and/or other conditions such as stress could be used to achieve the high perpendicular anisotropy for the free layer 330230. In addition, as discussed above with respect to the free layer 130', the free layer 230 can be synthetic. Consequently, the magnetic element 200 can be written using spin transfer at a lower switching current density. Stated differently, the magnetic element 200 can share the benefits of the magnetic elements 100, 100', 100'', 100''', and/or their combinations. Furthermore, when the pinned layers 210 and 250 are aligned antiparallel, both the spin valve portion 204 and the spin tunneling junction portion 202 can contribute to writing the free layer 230. Because of the use of the barrier layer 220, the magnetic element 200 has higher resistance and magnetoresistance. Consequently, a higher signal may be obtained during reading.

Page 24, line 21

The free layer 330 is preferably configured in a manner analogous to the free layers 130, 130', 130'', 130''', and/or the free layer 230. Thus, analogous materials and principles to those discussed above may be used to achieve the high perpendicular anisotropy of the free layer 330. For example, materials having a high crystalline perpendicular anisotropy and/or other conditions such as stress could be used to achieve the high perpendicular anisotropy for the free layer 330. Thus, the materials discussed above with respect to the free layers 130, 130', 130'', and 130''' are preferred. In addition, as discussed above with respect to the free layer 130', the free layer

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~~230~~330 can be synthetic. Because of the high perpendicular anisotropy, the magnetic element 300 can be written using spin transfer at a lower switching current density. Stated differently, the magnetic element 300 can share the benefits of the magnetic elements 100, 100', 100'', 100''' and/or their combinations. Because of the use of the barrier layer ~~340~~320, the magnetic element 300 has higher resistance and magnetoresistance. Consequently, a higher signal may be obtained during reading. In an alternate embodiment, the barrier layer 320 may be replaced by a conducting layer. However, in such an embodiment, the read signal is decreased for a given read current.

Page 25, line 14

In the magnetic element 300, the pinned layer 310 is synthetic. The pinned layer 310 thus includes ferromagnetic layers 312 and 316 separated by a nonmagnetic layer 314, which is preferably Ru. The nonmagnetic layer 314 is configured such that the ferromagnetic layers 312 and 316 are antiferromagnetically aligned. Furthermore, the magnetic element 300 is configured such that the ferromagnetic layer 316 and the pinned layer 350 are antiparallel. As a result, the spin valve portion 304 and the spin tunneling junction portion ~~310~~302 can both contribute to the spin transfer used to write to the magnetic element 300. Thus, an even lower switching current can be used to write to the magnetic element 300. In addition, because adjacent layers 312 and 350 have their magnetizations aligned parallel, the AFM layers 306 and 360 can be aligned in the same direction. The AFM layers 306 and 360 can, therefore, be aligned in the same step. Thus, processing is further simplified.

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Page 26, line 3

The free layers 230 and 330, as well as the magnetic elements 200 and 300, can be configured in an analogous manner to that discussed above. For example, Figure 5B depicts another version of the second embodiment 300' of a portion of a magnetic element in accordance with the present invention having a reduced write current density for spin transfer due to at least a high perpendicular anisotropy. The magnetic element 300' is analogous to the magnetic element 300 and, therefore, shares its advantages. For example, the free layer 330' has a high perpendicular anisotropy. Furthermore, in a manner similar to the magnetic element 100'', the magnetic element 300' includes stress increasing layer 380 that is analogous to the stress increasing layer 154. Although only the stress increasing layer 380 is depicted, another stress increasing layer could be used between the free layer 330' and the barrier layer 320'. However, such a layer would strongly reduce the tunneling magnetoresistance because this layer would lie adjacent to the barrier layer 320320'. With the use of the stress increasing layer 380 and/or, in an alternate embodiment, a stress increasing layer between the free layer 330' and the barrier layer 320', the high perpendicular anisotropy of the free layer 330' may be obtained. Thus, the benefits of the magnetic element 100'' may also be achieved.

Page 31, line 11

Furthermore, because the free layers 530 and 550 are magnetostatically coupled, a change in magnetization direction of the free layer 550, for example due to spin transfer induced writing, is reflected in the magnetization of the free layer 530. With the barrier layer 520, the spin tunneling junction 502 provides a high signal. In an alternate embodiment, the barrier layer

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~~320~~520 may be replaced by a conducting layer. However, in such an embodiment, the read

signal is decreased for a given read current.

Page 31, line 17

As previously mentioned, the free layers 530 and 550, as well as the magnetic element

500, can be configured in an analogous manner to that discussed above. For example, Figure 7B

is another version of the third embodiment of a magnetic element 500' in accordance with the

present invention having a reduced write current density for spin transfer due to at least a high

perpendicular anisotropy. The magnetic element 500' is analogous to the magnetic element 500

and, therefore, shares its advantages. For example, the free layers 530' and/or 550' have a high

perpendicular anisotropy. Furthermore, in a manner similar to the magnetic element 100'', the

magnetic element 500' includes optional stress increasing layers 582, 584 and 586 that are

analogous to the optional stress increasing layers 152 and 154. The bottom, the top, or both of

the optional stress increasing layers 582, 584, and 586 may be used. Although not depicted, an

optional stress increasing layer could be placed between the free layer 530' and the barrier layer

520'. However, such an optional stress increasing layer may result in a lower magnetoresistance.

In addition, use of the optional stress increasing layer 586 may result in a lower spin torque for

spin transfer as well as a lower magnetoresistance for the spin valve ~~504~~504'. Thus, the high

perpendicular anisotropy of the free layer ~~530''~~530' and/or ~~550''~~550' may be obtained. Thus,

the benefits of the magnetic element ~~100'''~~100'' may also be achieved.

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Page 32, line 14

Figure 7C depicts a third version of the second embodiment of a portion of a magnetic

element 500'' in accordance with the present invention having a reduced write current density for

spin transfer due to a high perpendicular anisotropy. The magnetic element 500'' is analogous to

the magnetic element 500 and, therefore, shares its advantages. For example, the free layer 530''

and/or 550'' have a high perpendicular anisotropy. Furthermore, in a manner similar to the

magnetic element 100''', the free layer(s) 530'' and 550'' include very high perpendicular

anisotropy ferromagnetic layer(s) 590 and 591, respectively, that are preferably analogous to the

very high perpendicular anisotropy ferromagnetic layer 160 depicted in ~~Figure 3C~~Figure 3B. The

free layer(s) 530'' and 550'' also include ferromagnetic layers 592 and 593 having a high spin

polarization. Additionally, a seed layer, such as AlCu 25nm, can be optionally inserted between

layers 540'' and 591 to help enhance the perpendicular anisotropy of layer 591. Furthermore, the

thicknesses of the very high perpendicular anisotropy ferromagnetic layer(s) 590 and 591 and the

ferromagnetic layer(s) 592 and 593, respectively, are preferably tailored such that the equilibrium

magnetizations of the very high perpendicular anisotropy ferromagnetic layer(s) 590 and 591 and

the ferromagnetic layer(s) 592 and 593 are in plane, as depicted. Thus, the very high

perpendicular anisotropy ferromagnetic layers 590 and 591 are preferably a rare earth-transition

metal alloy.

Page 33, line 8

Alternatively, the very high perpendicular anisotropy ferromagnetic layer(s) 590 and 591

can be multilayers [Co/Pd]n/Co, [Co/Pt]n/Co, [CoFe/Pd]n/CoFe, [CoFe/Pt]n/CoFe,

[CoCr/Pd]n/CoCr, or [CoCr/Pt]n/CoCr where n is between 1 and 10, Co 3A to 20A, CoFe 3A to

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20A, CoCr 3A to 20A, Pd 10A to 100A, Pt 10A to 100A. The repeat number n and the exact thicknesses of Co, CoFe, CoCr, Pd, and Pt are chosen so that the total perpendicular anisotropy energy is between twenty and ninety five percent of the total out-of-plane demagnetization energy of the free layer ~~130'''~~530'' and/or 550''. Thus, the high perpendicular anisotropy of the free layer 530'' and/or 550'' may be achieved. Consequently, the benefit of the magnetic element 100''' may also be provided.

Page 34, line 1

Figure 8 depicts a flow chart of a one embodiment of a method 600 in accordance with the present invention for providing one embodiment of a magnetic element in accordance with the present invention having a reduced write current density for spin transfer. The method 600 is described in the context of the magnetic element 100. However, nothing prevents the method 600 from being adapted to provide the magnetic elements 100', 100'', 100''', 200, 300, 300', 300'', 400, 500, 500', and/or 500''. A pinned layer, such as the pinned layer 110 is provided, via step 602. In one embodiment, step 602 includes providing a synthetic pinned layer. The spacer layer 120 is provided, via step 604. Step 604 can include providing a barrier layer or a conducting layer. The free layer 130 having a high perpendicular anisotropy is provided, via step 606. In some embodiments, the very high perpendicular anisotropy ferromagnetic layer or the stress inducing layer may be provided prior to step 606. Step 606 can include providing a synthetic free layer. In such an embodiment, step 606 may also include providing high spin polarization layers between the ferromagnetic layers of the free layer. If the magnetic elements 200, 300, 300', 300'', 400, 500, 500', and/or 500'' are being provided, additional pinned layers, spacer layers and, in some embodiments, free layers are provided, via step 608. In such

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embodiments, the free layers may have a high perpendicular anisotropy. Thus, the magnetic

elements 100', 100'', 100''', ~~100''''~~, 200, 300, 300', 300'', ~~300'''~~, 400, 500, 500', and/or 500'',

~~and/or 500'''~~ may be provided.

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